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Design of $H_3PW_{12}O_{40}/TiO_2$ and $Ag/H_3PW_{12}O_{40}/TiO_2$ film-coated optical fiber photoreactor for the degradation of aqueous rhodamine B and 4-nitrophenol under simulated sunlight irradiation

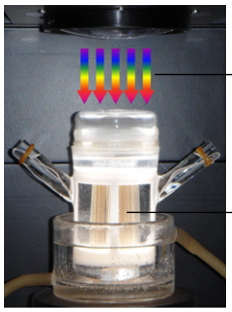
Shengqu Zhang [a,b], Ling Chen [a], Hongbo Liu [c], Wan Guo [a], Yuxin Yang [a], Yihang Guo [a,*], Mingxin Huo [a,*]

[a] School of Chemistry, Northeast Normal University, Changchun 130024, PR China
[b] Analytical and Testing Center, Beihua University, Jilin 132013, PR China
[c] Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033, PR China

HIGHLIGHTS

- $H_3PW_{12}O_{40}/TiO_2$ and $Ag/H_3PW_{12}O_{40}/TiO_2$-coated optical fiber photoreactor was designed.
- Designed optical fiber photoreactor worked efficiently under sunlight irradiation.
- Photocatalyst films coated on optical fibers can be reused without separation step.

GRAPHICAL ABSTRACT



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ABSTRACT

In order to improve sunlight-energy utilization efficiency of the photocatalyst for the degradation of organic pollutants in wastewater, a novel photoreactor that comprised $H_3PW_{12}O_{40}/TiO_2$ or metallic Ag deposited $H_3PW_{12}O_{40}/TiO_2$ film-coated optical fiber bundles was designed by the steps of sol–gel, hydrothermal treatment, photoreduction, and dip coating. The $H_3PW_{12}O_{40}/TiO_2$ or $Ag/H_3PW_{12}O_{40}/TiO_2$ film exhibited anatase phase, mesoporosity, and charge transfer band in the range of 200–400 nm or 200–800 nm. The photocatalytic activity of the $H_3PW_{12}O_{40}/TiO_2$ and $Ag/H_3PW_{12}O_{40}/TiO_2$ film-coated optical fibers was evaluated by the degradation of rhodamine B and 4-nitrophenol in aqueous solutions under the irradiation of commercial Xe lamp and self-made solar simulator ($320\ nm < \lambda < 680\ nm$). The enhanced photocatalytic activity of the $H_3PW_{12}O_{40}/TiO_2$ or $Ag/H_3PW_{12}O_{40}/TiO_2$ film in comparison of TiO_2 film was obtained and explained in terms of the synergistic photocatalytic effect between Keggin unit and TiO_2 as well as surface plasmon resonance effect of metallic Ag; and considerably high photocatalytic activity of the $H_3PW_{12}O_{40}/TiO_2$ and $Ag/H_3PW_{12}O_{40}/TiO_2$ film in the optical fiber photoreactor is explained by the superior light-energy utilization of the catalyst in the optical-fiber reactor. Finally, the reusability of the catalyst film was evaluated through six consecutive catalytic runs.

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1. Introduction

Wastewater treatment has a major impact on the sustainability of water resources. Wastewater is usually treated by the methodologies of ultrafiltration, biological degradation, activated carbon adsorption, nutrient removal, and chemical oxidation. The mentioned methods, however, are often ineffective to mineralize many

* Corresponding authors. Tel./fax: +86 431 85098705 (Y. Guo), tel.: +86 431 85099561 (M. Huo).
E-mail addresses: guoyh@nenu.edu.cn (Y. Guo), huomx097@nenu.edu.cn (M. Huo).

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